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ORIGINAL ARTICLE

Is compromised oral health associated with a greater risk of mortality among nursing home residents? A controlled clinical study

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Abstract
Aim The objective of this controlled clinical study was to evaluate the association between oral health and 1-year mortality among nursing home residents with or without oral health intervention.
Methods This research was part of a multidisciplinary intervention study (EVI-P) performed in 14 nursing homes in Germany. Two-hundred and nineteen nursing home residents were included in the study and assigned to an intervention group, for which dental health education was offered and ultrasonic baths were used for denture cleaning ($n = 144$), or to a control group ($n = 75$). Before the intervention, each participant was examined, and dental status, plaque control record (PCR), Denture Hygiene Index, and results from the Revised Oral Assessment Guide were recorded. Amount of care needed and dementia were also assessed, by use of the Barthel Index and the Mini Mental State Examination, respectively. Participant mortality was determined after 12 months, and bivariate analysis and logistic regression models were used to evaluate possible factors affecting mortality.
Results Bivariate analysis detected a direct association between greater mortality and being in the control group ($p = .038$). Participants with higher PCR were also more likely to die during the study period ($p = .049$). For dentate participants, the protective effect of being in the intervention group was confirmed by multivariate analysis in which covariates such as age and gender were considered.
Conclusion Oral hygiene and oral health seem to affect the risk of mortality of nursing home residents. Dental intervention programs seem to reduce the risk of 1-year mortality among nursing home residents having remaining natural teeth. Further studies, with larger sample sizes and evaluation of the causes of death, are necessary to investigate the reasons for these associations.

Keywords Oral health · Dental plaque · Nursing home · Mortality

Background

Ongoing demographic changes include trends toward a greater proportion of elderly people and an increased need for care. As a consequence, many elderly people live in nursing homes. Compromised oral hygiene is a major concern in long-term care, especially for those with motor and cognitive impairment and dementia.

In the long term, dental plaque causes periodontal disease and caries [1–3]. Caries has been found to be the most prevalent condition world-wide; periodontitis the sixth-most prevalent condition [4, 5]. Both diseases are, unfortunately, almost ubiquitous among care-dependent nursing home residents, and both lead to tooth loss. Tooth loss, in turn, leads to limited oral function, which is only partially, and inadequately, corrected by use of removable dentures [6]. Further reduction of chewing function and, therefore, nutrition may arise as a result of the ill-fitting and non-retentive dentures frequently encountered among nursing home residents [6].

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Periodontitis can also be directly correlated with several systemic diseases, for example diabetes mellitus and cardiovascular diseases [7–13]. Aspiration pneumonia, is another highly prevalent (50% of people aged >65 years), commonly plaque-induced, disease among the elderly, and it has been shown that the risk of pneumonia can be reduced by the reduction of dental plaque [14–16].

Systemic diseases, in turn, result in a greater risk of mortality. Among multimorbid elderly people, however, interactions among diseases and their effect on mortality are rather complex. Malnutrition, lower cognitive ability [17, 18], and greater care dependency [19] independently imply an increased risk of mortality. In addition to the risk of mortality from systemic diseases, some oral diseases have also been found to independently affect the risk of mortality [13, 14, 20, 21]. For patients suffering from periodontitis, a twofold greater risk of cardiovascular disease-related mortality and a fourfold greater risk of mortality from pneumonia have been reported in the literature [14, 16]. A greater risk of mortality has, furthermore, been detected among people with more dental treatment needs and signs of acute oral infections [22]. Oral health-related factors, for example retentive and well-fitting dentures or more natural teeth, have also been found to be associated with better nutritional status and lower care dependency [23–27], although improved chewing function does not inevitably result in improved nutrition [6].

Aim

As far as the authors are aware, no study has addressed possible independent risks of compromised oral health or possible protective factors, for example oral health intervention, on mortality among nursing home residents. The purpose of this controlled clinical study was to identify the effect of oral health on the mortality of elderly people living in nursing homes with or without oral health intervention.

Methods

Study setting and intervention implemented

The study protocol was approved by the local review board of the University of Heidelberg (registration number S-002/2012). This research was a part of controlled intervention study (EVI-P) performed in 14 nursing homes in South-Western Germany (federal state Baden-Württemberg). The ministry of social affairs randomized the nursing homes to intervention (eight homes) and control (six homes) groups. The nursing homes differed in location and capacity. The only inclusion criteria were that participants had to give written consent and had to have natural teeth and/or removable dental prostheses. Of the 14 nursing homes with a total of about 1000 residents (as the inclusion in the homes was consecutive this number varied), 269 residents fulfilled the inclusion criteria and were initially included in the study. Of the participants initially included, 50 refused assessment by use of the Mini Mental State Examination (MMSE) and were excluded from analysis of the results of the research (Fig. 1). The final number of participants analyzed thus was 219 (81%). The mean (SD; range) number of residents included, per nursing home, was 15.6 (8.1; 5–36).

In the intervention group ($n = 144$ participants) a 2-day oral health program was implemented including dental education, instruction in standardized assessment of oral health for non-dentists, and introduction of ultrasonic baths for denture cleaning [28]. In the intervention homes a total of 87 care givers participated in the educational part of the intervention. No interventions were performed in the control homes. Among participants in the intervention group, dental and denture hygiene improved substantially between baseline and 6-month follow-up whereas no changes of oral health were observed in the control group. The improvements of dental and denture hygiene in the intervention group were stable until the 12-month follow-up examination.

For ethical reasons the intervention was implemented in the control group after the end of the study.

Socio-demographic and medical data, care dependency, and dementia

Socio-demographic and medical data were obtained from care documentation. Age, gender, number of chronic diseases, and commonly taken medication were recorded. Participants' cognitive state was evaluated by four psychologists by use of the Mini Mental State Examination (MMSE) [29]. In this examination participants are asked to perform 30 tasks and are awarded one point for each task successfully completed, so the total score could range from 0 to 30. Scores equal to or below 20 are regarded as indicative of dementia [29]. Care dependency was evaluated by use of the Barthel Index (BI, score 0–100 points). To determine BI, the amount of care required to enable participants to perform activities of daily living (e.g., showering, eating, use of the toilet, etc.) was assessed. Higher scores imply less care dependency, and vice versa [30].

Assessment of oral health

Each participant underwent a comprehensive dental examination performed by two trained and calibrated dentists. This examination included assessment of dental status (number of natural teeth, type of denture). For analytical purposes, the type of denture was assigned to one of the three categories:

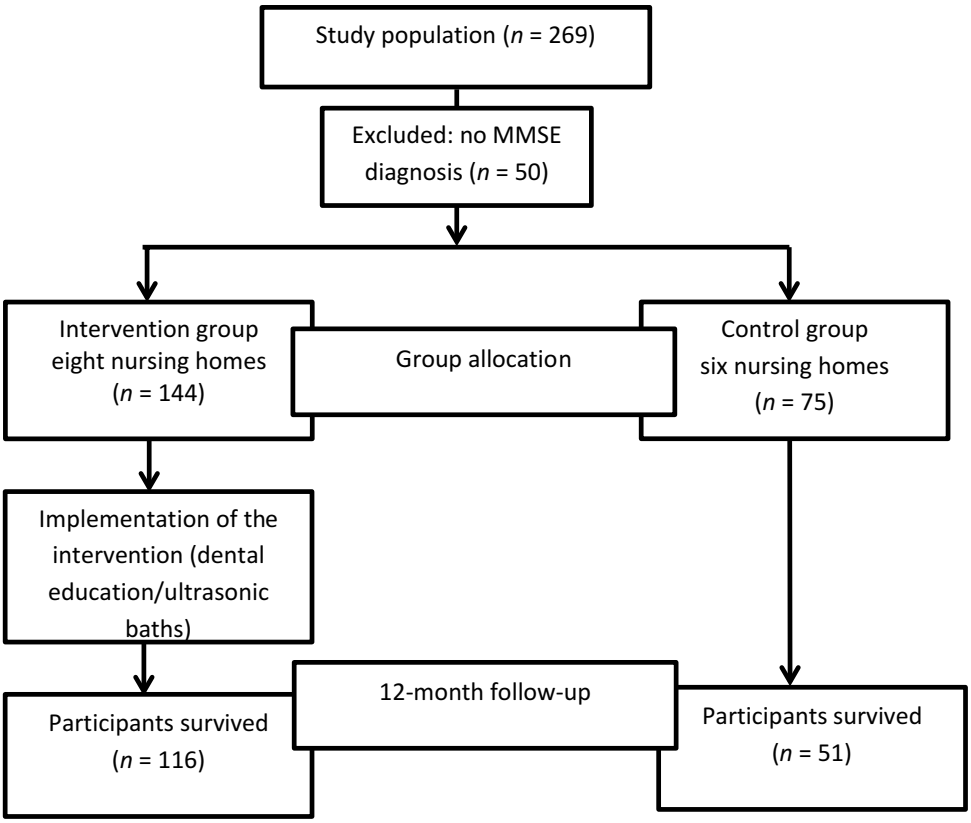

Fig. 1 Flowchart of participants

(1) natural teeth or fixed dental prosthesis (FDP); (2) removable dental prosthesis (RDP); (3) edentulous with complete denture (CD). This categorization 1., 2., or 3. based on the weaker kind of prosthesis are worn in maxilla and mandible (e.g., complete denture in the maxilla and RDP in the mandible = complete denture).

Oral hygiene was evaluated by use of the Plaque Control Record (PCR). Four sites of each tooth present were tinted with a plaque indicator (Mira-2-Ton; Hager & Werken, Duisburg, Germany). After rinsing with water, PCR was calculated as the ratio of plaque-positive sites to all available sites, expressed as a percentage [31]. The Denture Hygiene Index (DHI) was used to estimate denture hygiene [32]. To evaluate DHI, removable dentures were tinted with a plaque indicator (Plaque Test; Ivoclar, Schaan, Liechtenstein) and assessed by analogy with PCR.

Overall dental treatment needs were evaluated by use of the revised oral assessment guide (ROAG), a global indicator of oral health which enables easy evaluation of dental treatment needs by care givers and other dental lay-persons by use of a standardized scheme [33]. Use of the ROAG enables timely initiation of dentists' visits and, therefore, improvement of dental care for compromised nursing home residents. The examination includes assessment of saliva, swallow, speech, caries, mucosa, gums, denture retention, denture fitting, and denture condition. Each of these aspects was evaluated dichotomously (0 = healthy/1 = treatment needed; maximum 12 points). High scores therefore imply greater dental treatment needs [33].

Statistical analysis

Statistical analysis was performed, at the significance level of $\alpha < 0.05$, by use of SPSS version 23.0 (IBM Corp., New York, USA). Mortality (0 = survived, 1 = died) was investigated in relation to binary/dichotomized participant characteristics: age, systemic diseases, medication, dementia, care dependency, group membership, number of teeth, PCR, DHI, ROAG, and gender. The dichotomization of continuous variables was performed on the basis of a median test for each variable ($0 \leq$ median > 1). For bivariate comparison of mortality, chi-squared tests were used. In addition, binary logistic regression models were compiled with the dependent variable mortality and independent covariates (age, gender, intervention, etc.). One model was compiled for all participants ($n = 219$), one for participants with at least one natural tooth ($n = 141$), and another for participants with dentures ($n = 163$). The last two models were adjusted for the dichotomized covariates dental plaque (PCR) or denture plaque (DHI), respectively. All variables analyzed in the bivariate approach were also considered in the respective

multivariate analyses, with the exception of the covariate "denture status," for which high autocorrelation with the number of teeth was observed in both models for participants with dentures or natural teeth only.

Results

Study population

The mean (SD) age of the participants was 83.1 (9.0) years. Approximately 70% were female. The mean number of chronic diseases was 3.4 (2.2), and participants took a mean number of 6.5 (3.4) permanent medicaments. The mean (SD) Barthel Index for the participants was 49.5 (29.6) and the mean (SD) MMSE score was 15.8 (9.1). More than 70% of the participants had a removable denture of some kind in at least one jaw, and approximately 40% of the sample was completely edentulous in at least one jaw. The mean (SD) number of remaining teeth among the participants was 7 (8.4). Mean (SD) PCR was 85.4 (19.4), and the mean (SD) number of dental treatment needs was 2.3 (1.3). No differences were detected between the distributions of age, gender, number of diseases, level of care needed, PCR, number of teeth, and dental treatment needs in the intervention and control groups ($p > 0.05$); MMSE and drugs taken were, however, significantly different in the intervention and control groups (more drugs and lower MMSE in the control group). Analysis of data for participants without MMSE variable revealed comparable characteristics in both the analyzed ($n = 219$) and non-analyzed ($n = 50$) groups. The mean age of participants without the MMSE variable assessed was 83.2 (8.8) years ($p = 0.937$). During the study period 22% of the non-analyzed group and 23.7% of the study population died ($p = 0.793$).

Bivariate associations with mortality

During the year of observation 52 of the 219 participants died (1-year mortality 23.7%). Analysis of all the participants revealed that mortality was significantly higher in the control group ($p = 0.038$). During the study period, mortality in the intervention group was 19.4% (28 participants) whereas it was 32% (24 participants) in the control group. Eleven (of 144) participants in the intervention group and 14 (of 75) in the control group died within the first 6 months of the study ($p < 0.05$). Greater age and more dental treatment needs tended to be associated with greater mortality ($p = 0.067$; $p = 0.070$). Analysis of participants with natural teeth revealed that oral hygiene, as measured by PCR, was associated with greater mortality ($p = 0.049$; $n = 141$). Of the 141 participants with natural teeth, 29% of those who died had PCR above the median value; only 15% of those who died had PCR below the median. For denture hygiene (DHI), however, no association with mortality was detected ($p = 0.661$, $n = 163$). None of the other comparisons of

Table 1 Bivariate analysis of mortality and dichotomized target variables ($n = 219$)

	Number of living participants	Number of dead participants	Percentage of dead participants	p value
Age				
≤85	98	23	19.0	*0.067*
>85	69	29	29.6	
Gender				
Female	112	39	25.3	0.415
Male	55	14	20.3	
Diseases				
≤3	93	27	22.5	0.634
>3	74	25	25.3	
Drugs				
≤6	91	25	21.6	0.418
>6	76	27	26.2	
MMSE				
No dementia	65	18	21.6	0.576
Dementia	102	34	25.0	
Barthel Index				
<45	75	27	26.5	0.376
≥45	92	25	21.4	
Group membership				
Intervention	116	28	19.4	**0.038**
Control	51	24	32.0	
Number of teeth				
<4	87	31	20.8	0.302
≥4	80	21	20.1	
Denture status				
FDP	42	15	26.3	0.361
RDP	63	14	18.2	
CP/edentulous	62	23	27.1	
Dental plaque ($n = 141$)				
≤93.2%	61	11	15.3	**0.049**
>93.2%	49	20	29.0	
Denture plaque ($n = 163$)				
≤85.0%	64	21	24.7	0.661
>85.0%	61	17	21.2	
ROAG				
≤2	107	26	19.5	*0.070*
>2	60	26	30.2	

Significant p values are marked in bold

Trends are marked in italics

FDP fixed dental prosthesis, *RDP* removable partial dental prosthesis, *CP* complete denture or, for edentulism, no dentures

mortality reached statistical significance ($p > 0.05$). Detailed results from these analyses are presented in Table 1.

Risk factors for 1-year mortality

The bivariate effect of lower mortality for participants in the intervention group was confirmed by multivariate analyses for all participants and for participants with natural teeth remaining (Tables 2, 3). The effect could not be reproduced in the model for denture wearers ($p = 0.106$). The logistic regression model (all participants) revealed a twofold greater risk of mortality in the control group (95% confidence interval (CI) 1.0–4.1; $p = 0.043$). The second model (dentate participants only) revealed an even greater risk factor of 3.5 for participants in the control group ($p = 0.009$). The strength of the association of more dental treatment needs (ROAG) with mortality varied from $p = 0.033$ for denture wearers to $p = 0.093$ for dentate participants. When dentate participants, only, were analyzed the covariate age also became significant ($p = 0.044$) with a 2.5-fold mortality risk for participants older than the median. In this model, dental plaque, as measured by PCR, lost its significant effect on 1-year mortality ($p = 0.101$). The multivariate logistic regression model for participants with any kind of denture also revealed an association between the ROAG and mortality ($p = 0.033$). Age also tended to be associated with mortality ($p = 0.075$). In this model, group membership did not affect the risk of 1-year mortality (Table 4). In all three models, none of the other covariates affected mortality.

Discussion

The results of this study suggest that some aspects of oral health are associated with a greater risk of 1-year mortality among nursing home residents, and that oral health intervention might reduce this risk. The risks factors seem to depend on dental status (dentate/edentulous), however.

Among dentate participants, besides the protective effect of being in the intervention group, age, also, was associated

Table 2 Multivariate logistic regression model with mortality as the dependent variable and independent dichotomized covariates for all participants ($n = 219$)

95% CI				
Confounder	Odds ratio	Lower border	Upper limit	*p* value
Age > median	1.7	0.9	3.4	0.114
Female	1.0	0.5	2.2	0.977
Diseases > median	1.1	0.6	2.1	0.797
Drugs > median	1.2	0.6	2.2	0.656
Barthel Index < median	1.1	0.6	2.3	0.714
Dementia	1.2	0.6	2.5	0.613
Control group	2.1	1.0	4.1	**0.043**
Number of teeth > median	0.9	0.4	1.7	0.599
Denture status	1.3	0.8	2.0	0.222
ROAG > median	2.0	1.0	3.9	*0.050*

Significant *p* values are marked in bold, trends are marked in italics

Table 3 Multivariate logistic regression model with mortality as the dependent variable and independent dichotomized covariates for dentate participants, PCR available, only ($n = 141$)

95% CI				
Confounder	Odds ratio	Lower border	Upper limit	*p* value
Age > median (84 years)	2.5	1.0	6.3	**0.044**
Female	1.5	0.6	4.0	0.423
Diseases > median	1.3	0.5	3.3	0.560
Drugs > median	1.2	0.5	3.0	0.635
Barthel Index < median (50 units)	1.2	0.5	3.1	0.670
Dementia	0.8	0.3	2.2	0.722
Control group	3.5	1.4	8.8	**0.009**
Number of teeth > median (eight teeth)	0.8	0.3	2.1	0.674
ROAG > median	2.3	0.9	6.0	*0.093*
Dental plaque > median	2.3	0.9	6.0	*0.101*

Significant *p* values are marked in bold, trends are marked in italics

PCR plaque control record

Table 4 Multivariate logistic regression model with mortality as the dependent variable and independent dichotomized covariates for participants with any kind of dentures (DHI available; $n = 163$)

		95% CI		
Confounder	Odds ratio	Lower border	Upper limit	*p* value
Age > median	2.1	0.9	4.8	*0.075*
Female	0.6	0.2	1.7	0.334
Diseases > median	0.8	0.4	1.8	0.610
Drugs > median	1.0	0.5	2.2	0.980
Barthel Index < median (50 units)	1.7	0.7	3.9	0.227
Dementia	1.0	0.4	2.4	0.992
Control group	2.1	0.9	4.9	0.106
Number of teeth > median (zero teeth)	1.2	0.5	2.6	0.698
ROAG > median	2.3	1.1	5.2	**0.033**
Denture plaque > median	0.8	0.3	1.7	0.491

Significant *p* values are marked in bold, trends are marked in italics

DHI denture hygiene index

with 1-year mortality, which is not surprising for this study population. Age is also associated with a greater probability of more severe chronic diseases, cognitive impairment, and care dependency, all of which have been proven to increase the risk of mortality [17–19].

Group membership, however, had the strongest association with mortality among participants with remaining natural teeth, which raises questions about the causes. Because participants in the control group had lower cognitive ability one might speculate that this affected mortality. When dementia was used as an independent covariate in the regression analysis it was not significant, however. The same was true for the different numbers of frequently taken drugs in the groups. Reduction of dental plaque—stable until the end of the study—was observed for participants in the intervention group [28]; because more participants with PCR above the median died during the study period, one might expect this was the reason for the association between lower mortality and being in the intervention group. This result might be explained by studies which reported effects of dental plaque, periodontitis, and oral infections on such systemic diseases as pneumonia, diabetes mellitus, and cardiovascular diseases [7–11] all of which, in turn, increase the risk of mortality [13–16, 20, 21]. Cardiovascular diseases, for example cardiac infarction, and pneumonia are common causes of death among elderly people. One might also speculate that dental plaque aggravates existing chronic diseases and, therefore, results in a greater risk of mortality, especially among compromised nursing home residents. The greater risk of mortality of participants with the worse oral hygiene could not, however, be reproduced in multivariate analysis ($p = 0.101$). This is probably accounted for by the rather small sample size (participants with natural teeth). Another interesting result is that denture plaque did not affect mortality (in either bivariate or multivariate analysis). This might, however, indicate that plaque located close to oral soft tissue is more likely to promote diseases which, in turn, lead to a greater risk of mortality. Another interesting finding is that in the multivariate model for denture wearers—in contrast with the main model and the model for dentate participants only—group membership had no significant association with mortality. This, however, also implies that mortality is, instead, linked to dental problems.

Because of correlations of mortality with number of teeth, nutrition, and dependency suggested in the literature [23–27], number of teeth might also have been expected to be associated with mortality [25, 26]. In this study, however, number of teeth was not a significant predictor of mortality. Any possible effect might be less important than tooth-related risk factors, for example more difficult oral hygiene for complex dentition and, therefore, probably greater plaque accumulation, especially among nursing home residents with a high need for care. The opposite positive association of better chewing function with more teeth and therefore maybe a better nutritional state and lower mortality might have compensated for any possible effect. The non-significance of the covariate denture status in the main model supports this idea. However, the analysis of nutritional parameters would have been an interesting issue and should be considered in further research.

Despite complicating risk factors, dental-related treatment needs may affect the risk of mortality [22]. When Hämäläinen et al. investigated the relationship between dental treatment needs and mortality among community-dwelling elderly people they found a positive association between mortality and an urgent need for dental treatment [22]. In our study, greater dental treatment needs, evaluated by use of the ROAG, did not affect the risk of participant mortality, although a substantial trend was observed ($p = 0.05$). When only participants with removable prostheses were analyzed, however, dental-related treatment needs significantly affected mortality ($p = 0.033$). Because

the ROAG assessment also includes fitting and retention of dentures, and mucosal lesions, etc., this instrument might be more sensitive for edentulous people, who are prone to more compromising oral health problems. Nonetheless, with regard to multivariate analysis for all participants, the discrepancies between our results and those of Hämäläinen et al. might be explained by different definitions of "dental treatment needs." In contrast with our study, Hämäläinen et al. used their own definition, in which "pain, infections and bad conditions with serious consequences" were defined as dental treatment needs.

In summary, the results of our study suggest that oral health and systemic health problems are a complex combination which exacerbate each other. Elderly people with more natural teeth might have better chewing function and, therefore, better nutrition and greater independence; if, therefore, plaque accumulation is also lower for this group, they will be at lower risk of mortality [16, 20, 23]. In contrast, worsening oral hygiene, which is common among elderly people as a result of compromised ability to perform dental care, leads to greater plaque accumulation and an increased risk of caries and periodontitis, which may promote chronic diseases and, therefore, mortality [11, 20]. Being edentulous can also be problematic, however, even though dental plaque is absent. Ill-fitting and non-retentive dentures can lead to malnutrition, resulting in greater dependency and mortality [24–26]. This idea is, again, supported by the significant association between ROAG and mortality among denture wearers found in this study.

Strengths and weaknesses of the study

The sample is a sub-population from a large, representative, interdisciplinary study initiated by the Ministry of Social Affairs of the state of Baden–Württemberg, Germany, and the examinations were performed by calibrated dentists. A limitation of the study is that only approximately 20% of the residents living in the study nursing homes gave written and oral consent or fulfilled the other inclusion criteria (natural teeth and/or removable prostheses) and could therefore be included into the study. This suggests caution in interpretation and generalization of the results. It is possible that participants were more interested in their oral health or had more acute dental problems than non-participants. All residents' homes who gave consent were included in the study. It should be recognized that the comprehensive medical, psychological, and dental examinations were time-consuming (~2 h) which definitely led to concerns about participation in many cases.

Beside these limitations it should be kept in mind that the medical data were extracted from care documentation. Furthermore, a shortcoming of the study is that the cause of mortality and the exact moment of dying of the nursing home residents were not recorded and analyzed in this study.

Conclusion

Despite the limitations of this study, one can conclude, with caution, that some oral problems increase the risk of mortality of nursing home residents. The risk factors tend to depend on dental status (dentate/edentulous). Among denture wearers, for example, dental treatment needs seem to be associated with mortality. For dentate people, especially, age seems to be a risk factor while the implementation of intervention programs intended to improve oral hygiene seems to be an independent protective factor for 1-year mortality of nursing home residents. However, further studies with greater sample size are necessary to validate this association and to determine specific reasons for these effects.

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Author contributions AZ and AJH designed the study and undertook the statistical analyses. PR and JS were involved in the design of the study and in data interpretation. A-LK managed the literature searches and wrote the manuscript. All the authors contributed to and approved the final paper. All the authors contributed to data analysis, drafting, and critical revision of the paper, and have agreed to be accountable for all aspects of the work.

Compliance with ethical standards

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Conflict of interest Andreas Zenthöfer has received research grants from the Ministry of Social Affairs of Baden-Württemberg but reports no conflict of interest. All other authors report no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from each participant in the study.

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